



GOLD-CATALYZED CYCLOISOMERIZATION REACTIONS OF VINYLALLENE DERIVATIVES

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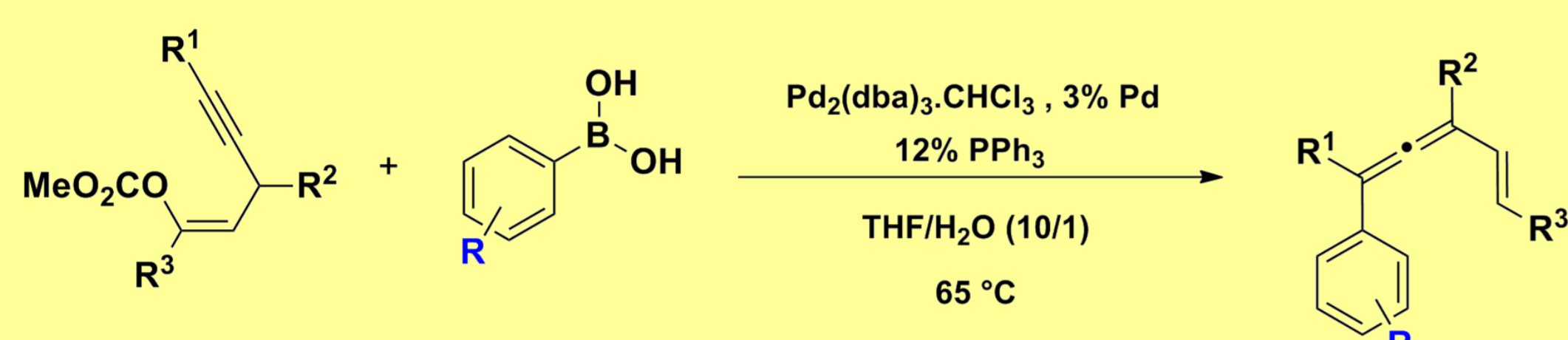
Introduction

The gold-catalyzed cycloisomerization reactions of α -hydroxyallenes have been established by our group.^[1] Several useful methods for the synthesis of vinylallene derivatives have also been reported.^[2] Vinylallenes were found to undergo gold-catalyzed cycloisomerization reactions to give cyclopentadiene derivatives.^[3]

In this study, the gold-catalyzed cycloisomerization reactions of α -hydroxy-vinylallenes and vinylallenes which bear electron-donating or -withdrawing groups on the aryl group have been studied to investigate the effect of the vinyl part and the aryl moiety on the cyclization reactions.

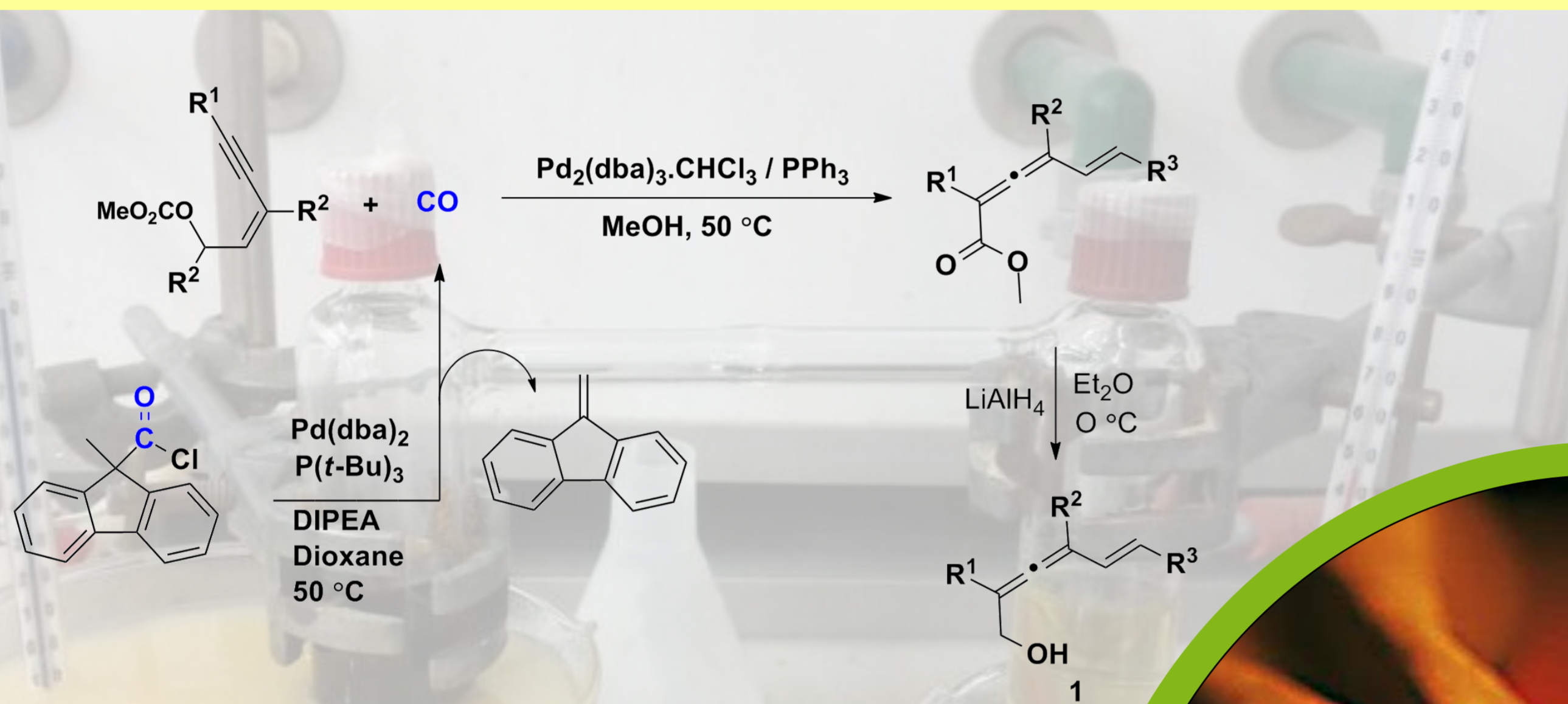
Results

The vinylallene derivatives were synthesized by the Pd-catalyzed reaction of 2-en-4-yne carbonates with organoboronic acid. The method has large scope for both organoboronic acids and enyne substrates.^[4]

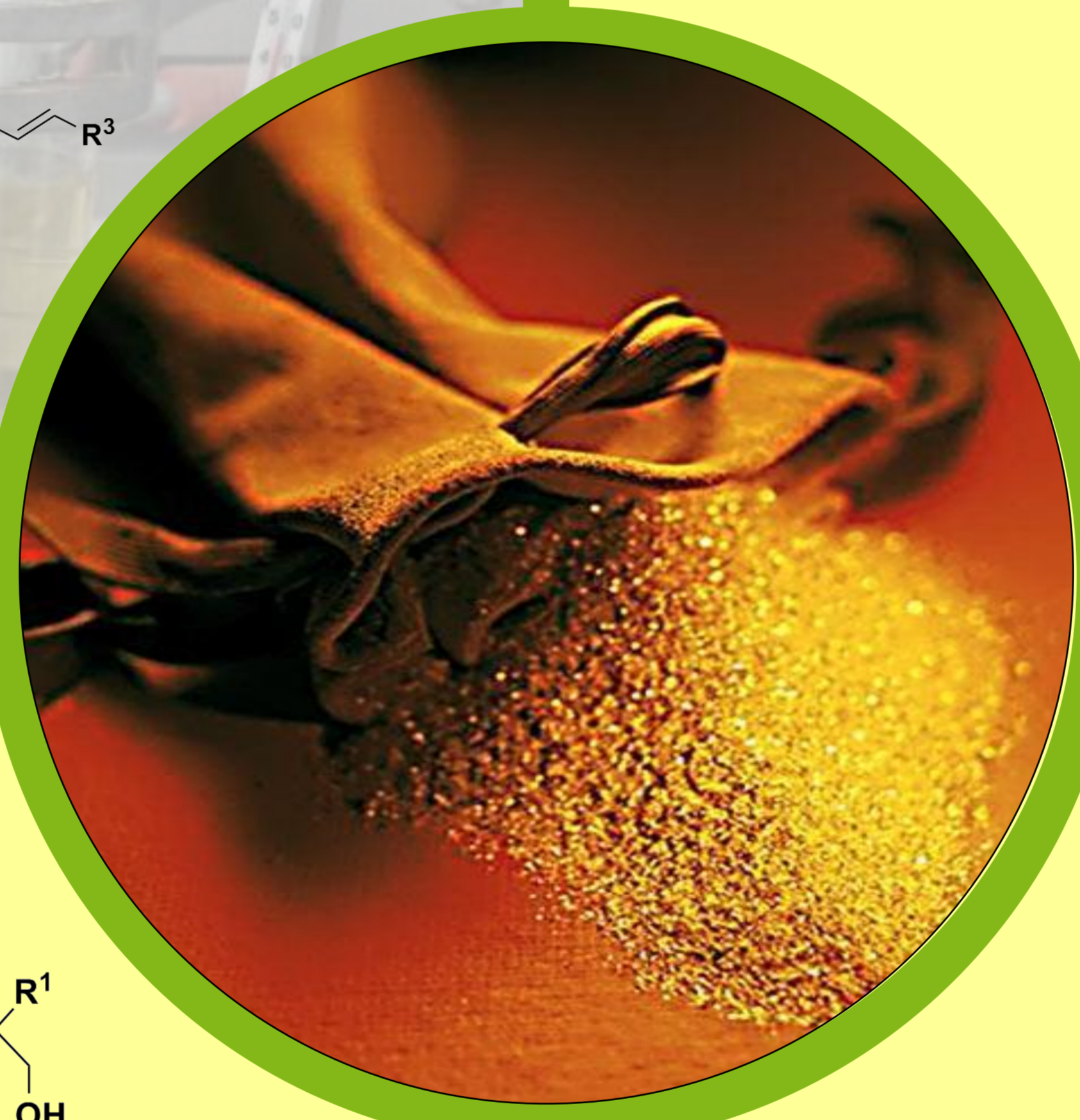


Scheme 2. Pd(0)-Catalyzed Reaction of (Z)-Enyne Carbonates with Organoboronic acids.

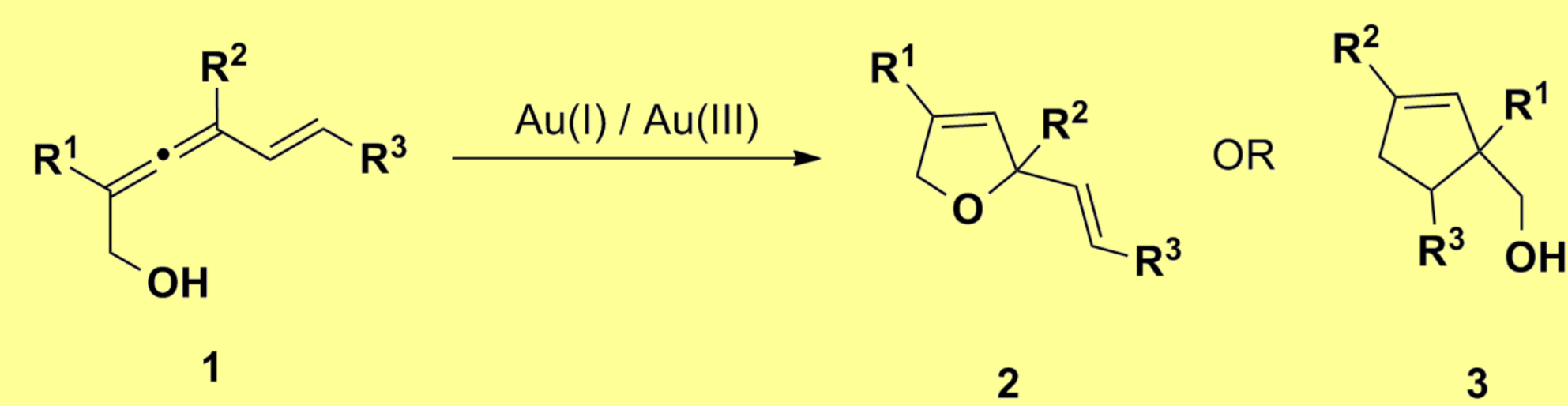
The *ex-situ* generation of CO technique was applied to synthesize the α -hydroxy-vinylallenes *via* palladium-catalyzed carbonylation reactions of the 2-en-4-yne carbonates in the presence of alcohol.^[5,6]



Scheme 3. Synthesis of 1 by using CO precursor.



Based on our interest in the gold-catalyzed cycloisomerization reactions of various allene derivatives, in this part of the project α -hydroxy-vinylallenes were subjected to gold-catalyzed cycloisomerization reactions to investigate the effect of the vinyl group.



Scheme 4. Gold-catalyzed cycloisomerization of α -hydroxy-vinylallenes.

The gold-catalyzed cycloisomerization reactions of 1 afforded only the formation of vinyl-2,5-dihydrofuran derivative 2. According to our preliminary results entry 3 shows the best conditions for the formation of 2a.

Table 2. Effect of the catalyst on the gold-catalyzed cycloisomerization of 1a.

Entry	Catalyst	Solvent	Yield [%]
1	5% PPh ₃ AuCl / 5% AgBF ₄	CH ₂ Cl ₂	40
2	AuCl ₃	CH ₂ Cl ₂	35
3	5% PPh ₃ AuCl / 5% AgBF ₄	Toluene	73
4	10% PPh ₃ AuCl / 10% AgBF ₄	Toluene	71

Further catalyst screening will be extended to investigate the effect on the formation of 3 instead of 2.

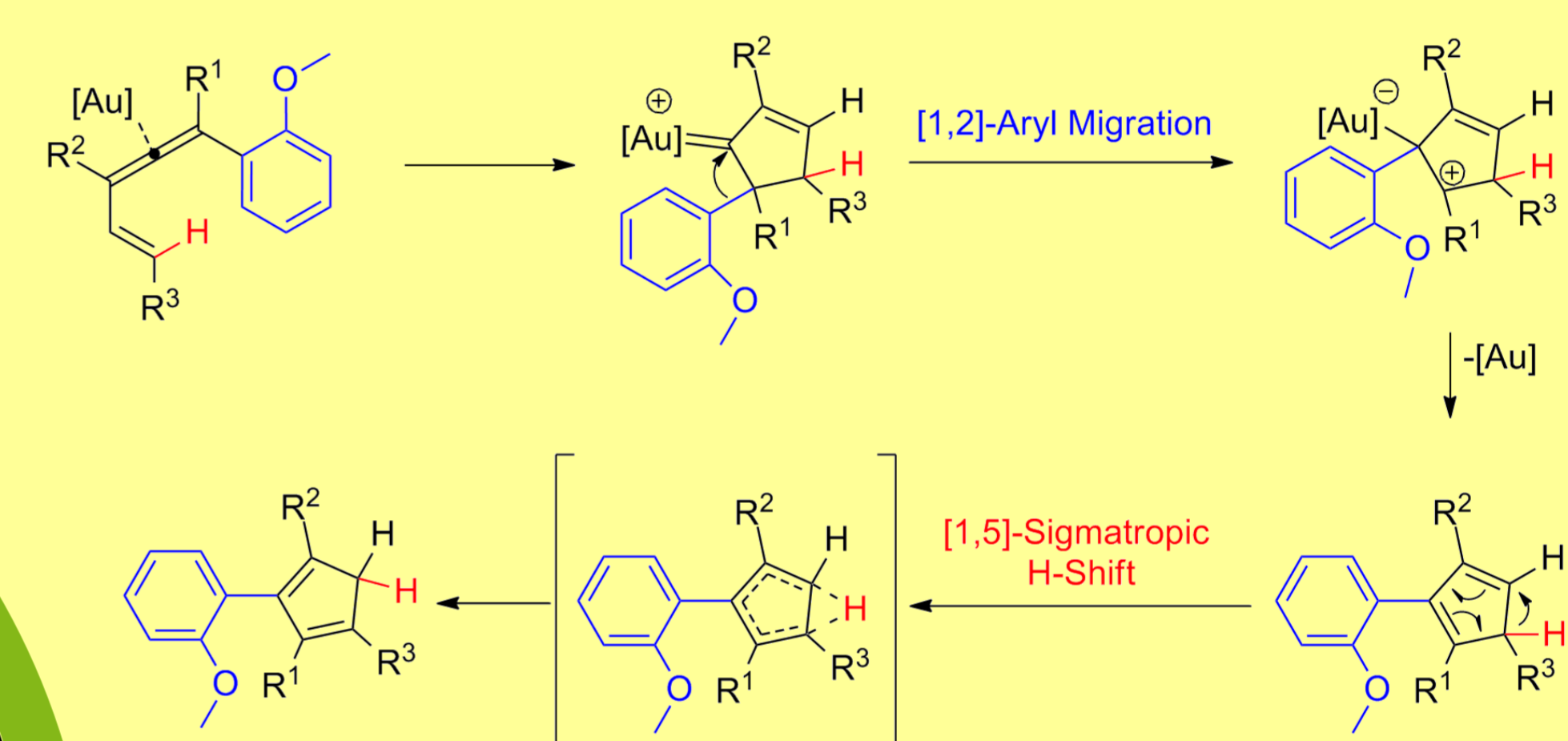
Furthermore, vinylallenes which bear electron-donating or withdrawing groups on the aryl moiety were subjected to the gold-catalyzed cycloisomerization reaction to examine the effect of the substituents on allenic and aryl moiety.

Gold-catalyzed cycloisomerization reactions of 4a afforded the formation of cyclopentadiene derivative 5a. The best result of the cycloisomerization product 5a was obtained by using the cationic gold(I) complex which was generated *in situ* from PPh₃AuCl and AgSbF₆.

Table 2. Effect of the catalyst on the gold-catalyzed cycloisomerization of 4a.

Entry	Catalyst	t [min]	Yield [%]
1	PPh ₃ AuCl / AgSbF ₆	10	83
2	AuCl ₃	120	-
3	AgBr ₃	120	-
4	AuCl	120	-
5	IPrAuCl / AgSbF ₆	15	76
6	PPh ₃ AuCl	120	-
7	AgSbF ₆	120	-

For the mechanism, we propose that after the coordination of gold-catalyst and cyclization, [1,2]-Aryl migration and [1,5]-Sigmatropic Hydrogen-shift take place.



Scheme 4. Proposed mechanism for the gold-catalyzed cycloisomerization.

The scope of the cycloisomerization method was surveyed for a range of vinylallene derivatives bearing different substituents on the allenic and vinylic positions.

Table 3. Effect of substituents on the gold-catalyzed cycloisomerization of 4.

Entry	Substrate	R ¹	R ²	R ³	R ⁴	t [min]	Yield [%]
1	4a	OMe	Bu	Me	Me	5	83
2	4b	OMe	Ph	Me	Me	5	90
3	4c	OMe	<i>t</i> -Bu	Me	Me	120	- ^a
4	4d	OMe	Bu	Me	<i>i</i> -Pr	120	57
5	4e	OMe	Bu	Me	Bu	5	78
6	4f	OMe	Me	Me	Me	120	- ^a
7	4g	OMe	2-FPh	Me	Me	15	52
8	4h	OMe	2-MePh	Me	Me	15	- ^a
9	4i	OMe	2-ClPh	Me	Me	30	- ^a
10	4j	-	2-FPh	Me	Me	10	- ^a
11	4k	-	Ph	Me	Me	15	- ^a
12	4l	Me	Bu	Me	Me	15	- ^a
13	4m	F	Bu	Me	Me	45	- ^a
14	4n	-	Bu	Me	Me	10	- ^a

^a) decomposition

In conclusion, vinylallene derivatives 1 and 4 were subjected to the gold-catalyzed cycloisomerization reaction. Our preliminary results indicate that the reaction of 1 affords the formation of vinyl-2,5-dihydrofuran derivatives. Cyclopentadiene derivatives 5 could be synthesized by the gold-catalyzed cycloisomerization reaction of 4. Furthermore a mechanism containing [1,2]-Aryl migration and [1,5]-Sigmatropic Hydrogen-shift has been proposed.

References

[1] (a) A. Hoffmann-Röder, N. Krause, *Org. Lett.* **2001**, *3*, 2537. (b) N. Krause, A. Hoffmann-Röder, J. Canisius, *Synthesis* **2002**.
 [2] (a) A. Hoffmann-Röder, N. Krause, *Org. Biomol. Chem.* **2005**, *3*, 387. (b) R.A. Widenhoefer, X. Han, *Eur. J. Org. Chem.* **2006**, 4555.
 [3] J.H. Lee, F.D. Toste, *Angew. Chem. Int. Ed.* **2007**, *46*, 912.

[4] M. Üçüncü, E. Karakuş, M. Kus, G.E. Akpınar, Ö.A. Artok, N. Krause and L. Artok, *J. Org. Chem.* **2011**, *76*, 5959.
 [5] P. Hermange, A. Lindhardt, T. Skrydstrup, *J. Am. Chem. Soc.* **2011**, *133*, 6061.
 [6] G.E. Akpınar, M. Kuş, M. Üçüncü, E. Karakuş, L. Artok, *Org. Lett.* **2011**, *13*, 748.